Independent Double Check

Test Report

Exploration of 2 Double-Check Methods

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SUMMARY

Introduction

Medical products that are designed with little or no consideration for human factors are a major factor in the occurrence of medication errors. Some recognition of this is beginning to influence the way in which medical device and pharmaceutical companies design their products. Until sweeping changes are made, however, health care facilities must continue to manage the risk posed by such products. For this reason, more immediate solutions such as independent double-checks are necessary. This report describes a usability test that was conducted as part of ISMP Canada's Narcotics project.

Methods

The focus of the study was a comparison of 2 methods of independent double-checking: (1) the flow sheet method and (2) the verbal read-back method. The study used patient-controlled analgesia pumps as a test bed. In the flow sheet method, the nurse conducting the double-check uses a flow sheet (or monitoring form) to record settings from a pump, which are then checked against the order form. In the verbal read-back method, the nurse conducting the double-check reads the pump settings for another nurse to check against the order form. The testing was conducted in the usability laboratory at a large teaching hospital.

Four teams of 2 nurses participated in the usability test. The teams were trained in the application of each method, and then were asked to check 12 patient-controlled analgesia (PCA) pump set-ups against 12 order forms, using the flow sheet method for 6 of the checks, and the verbal read-back method for the other 6 checks. The order in which the teams carried out the double-checks (flow sheet method first or read-back method first) was counterbalanced. The PCA pumps were pre-programmed by the usability test team. Several of the pump settings were intentionally programmed incorrectly to determine if the teams could detect the errors using the double-check methods. The participants were briefed after the double-checks were completed and were asked a series of questions about the 2 methods.

Results

The 2 methods were equally effective in detecting programming errors (28 [88%] of the 32 errors were detected). All of the 4 programming errors that went undetected were concentration errors; in 3 of the 4 undetected errors, the pump was incorrectly set for microgram quantities. That this error eluded detection by 3 of the 4 teams during their double-checks suggests that modifications to order forms or double-check tools are needed to address this type of error. Most of the nurses preferred the verbal read-back method for double-checking. The reasons for this preference went well beyond the anticipated reason of speed. First, although many nurses deemed the flow sheet method an effective way to catch errors, many expressed a sense of responsibility for the flow sheet and were not comfortable asking a peer to take over that responsibility. Second, they also felt uncomfortable using the flow sheet (instead of the pump) to verify settings against the order form. Third, finding a discrepancy between the order form and flow sheet created the need to verify the accuracy of the flow sheet, which added to the complexity of the double-check process, with 3 sources of information (order form, flow sheet, and pump) to be compared rather than just 2 (order form and pump). Fourth, the read-back method was most similar to existing processes of double-checking, whether formal (policy driven) or informal.

Design Implications

The findings of this study have implications for the design of double-check systems (including policies, forms, and training materials) that are effective, efficient, and reliable in catching errors. The following design implications can be drawn from this study:

1. Develop tools to guide double-checks that nurses do together, in addition to those done independently.
2. Ensure that the process does not require handing off forms to a second person.
3. Avoid requiring nurses to consider a third source of information.
4. Ensure consistency (in information sequence and terminology) between the pump, order form, and flow sheet.
5. Provide a specific prompt to look at the cassette.
6. Provide a specific prompt to look at units (e.g., micrograms or milligrams).
7. Lay out the order form to promote strategies that reduce cognitive load.

Recommendations

This report concludes with a series of recommendations for modifying the independent double-check process and tools to support such a process. Summarized below, these recommendations are based on the design implications drawn from the usability test as well as human factors research on checklist design:

1. Allow a read-back format for conducting an independent double-check, but that read-back process should be guided by a list of variables to be checked (e.g., a checklist).
2. The checklist should be embedded in the order form.
3. The checklist should be organized in a way that is familiar to nurses, and should promote strategies for reducing cognitive load (e.g., by incorporating shortcuts for experienced users).
4. The order of items in the checklist should correspond to the order in which items appear on the pump or the order form.
5. Little or no training should be required to use the checklist, which should represent a visual reminder to carry out specific activities or tasks.
6. The checklist should be explicit in terms of the manner in which it is read out and in which the response is made.
7. In general, the most critical items on the checklist should appear as close to the beginning of the list as possible.
8. The final item on the checklist should represent completion of the checklist (for instance, signature by the responsible staff member).

INTRODUCTION

Patient care in modern health care settings consists of many complex processes that employ a variety of products and equipment designed by different manufacturers. This variation presents difficulties to health care practitioners. Finding information about medications, for instance, is made unduly complex by the variety of ways in which manufacturers use font, colour, layout, and other features on packaging and labels. The medication administration process is one of many processes in health care affected by this situation. Look-alike or sound-alike drugs are common, which creates opportunities for confusion. These issues are compounded by the high-risk nature of some medications. Because there is no quick and easy way of changing how manufacturers design their products, challenges will persist in everyday practice.

Performing double-checks is one method of adding another layer of protection so that harm does not reach the patient. However, the way in which double-checks are carried out varies widely. At one end of the spectrum, double-checks are carried out completely independently, that is, 2 people separately and individually verify the patient, medication, concentration, dose, time, and route. This independent verification is preferred because it generally prevents one practitioner from biasing the other. The bias may come from many sources: trust in a peer's competence (whereby anything more than a casual glance may be construed as mistrust); a belief that errors are rare, so there is no compelling reason to be highly vigilant; the impossibility of maintaining a constant state of vigilance; the routine use of drugs, such that nurses fall into a pattern of retrieving medications according to "cues" such as general appearance of the package rather than reading the packages every time; and knowledge of what the settings should be, which leads to the perception that the expected settings are present.

At the other end of the spectrum is the less independent method of checking, whereby a nurse holds up the product for a second nurse to see, saying, "I have morphine 2, right?" A glance and nod of the head constitutes the check. This method is much more prone to the biases described above. Nurses may resort to this method of checking for many reasons. First and foremost, there may not be any other formally taught method of checking, but there are other reasons:

- High task demands and time pressure provide few incentives to carry out an independent check.
- Many other tasks in nursing practice require that nurses communicate information to each other; as such, temporarily *withholding* information for the purpose of an independent double-check is not necessarily intuitive or consistent with norms of practice.
- Since a double-check requires 2 people, it is deemed to be a task that is done "together"; leaving a colleague to double-check your work may be viewed as delegating responsibility to someone else.

In practice, double-checks are probably performed in a manner somewhere in the middle of this spectrum. Recognizing the wide variation in practice, ISMP Canada wanted to explore other ways of carrying out a double-check that would encourage more independence and thus minimize bias. Two methods of double check were identified as candidates: the flow sheet method and the verbal read-back method.

In the **flow sheet method**, one nurse programs the patient-controlled analgesia (PCA) pump and then hands a blank flow sheet to a second nurse, who fills out the flow sheet according to the settings of the pump, *without* knowledge of the original order form (which could present bias). Together, the 2 nurses then compare the order form with the flow sheet to ensure there are no discrepancies.

In the **verbal read-back method**, one nurse programs the PCA pump and then asks a second nurse to read out the settings on the pump (again, without knowledge of the settings on the original order form); the first nurse compares the values read out by the second nurse with the values on the order form.

Although bias cannot be eliminated entirely with either of these 2 methods, the intent was to minimize the bias that does occur. Introduction of any new process has intended and unintended consequences, and it is important to understand both types. Therefore, usability tests were designed and carried out to capture both qualitative and quantitative data on the use of these methods. The purpose of this study was to explore these 2 methods of double-checking. Performance data, including task time, reliability in catching errors, difficulties in carrying out the double-check tasks, and preferences, were recorded. Usability testing was conducted at a large teaching hospital on November 29, 2004.

METHODS AND MATERIALS

Participants

A total of 8 nurses participated, 6 of whom were from the large teaching hospital where the usability testing took place and were experienced in programming the PCA pump used in the study. They were also familiar with the order forms and flow sheets used. Two nurses recruited from another large teaching hospital were not familiar with this model of pump or the order forms but had experience programming other pumps.

Materials

One model of PCA pump was chosen for the study, the Abbott Lifecare 4100 PCA Plus II. This pump is currently used at the first hospital, and most participants did not require training in its use. The 2 nurses who were not familiar with the pump received instruction on how to call up the pump settings to perform the double-check.

Two pumps (of the same make and model) were used during the test. While one pump was being double-checked by participants, the members of the usability test team prepared and programmed the second pump for the next trial. Preprinted PCA order forms and flow sheets from the first hospital were used. The order forms were completed in advance with values typically prescribed at the hospital. A total of 12 order forms and 12 flow sheets were prepared for each team. A list of the materials used in the study appears in Appendix A.

Test Site

The usability tests were conducted in the usability laboratory at the first teaching hospital. The lab consisted of a mock-up of a patient room, complete with bed and patient mannequin. Unobtrusive cameras and microphones were mounted on the ceiling to capture the test process. Observers were seated behind a one-way mirror that allowed unobtrusive viewing. A wall separated the participants from the usability test team who were setting up the pumps for each trial.

Method

The nurses were divided into 4 teams of 2 members each, and the teams performed the usability test one at a time. Each team was given a brief verbal introduction (Appendix C). Teams were divided into 2 groups. Group 1 (teams 1 and 3) used the flow sheet method first, then the verbal read-back method. Group 2 (teams 2 and 4) used the verbal read-back method first, then the flow sheet method. Each team received instruction on the first method (Appendix D) and was given an opportunity to practise using a sample order form, flow sheet, and pump. Nurses were assigned to be either nurse 1 (the person asking for the double-check) or nurse 2 (the person carrying out the double-check). Teams then conducted double-checks of 6 pump set-ups (switching roles halfway through the sequence). Pumps were programmed by the test team behind a wall before each trial. The participant teams could hear but not see this activity. Pump alarms went off intermittently in the background (an unintentional though realistic component of the environment). Instruction on the second method was given after the first 6 trials and the nurses were allowed to practise this method using a sample order form, flow sheet, and pump. The teams then conducted double-checks of

6 more pump set-ups (switching roles halfway through the sequence). The protocol can be found in Appendix B.

Performance Data

The following performance variables were recorded or observed:

- **Task time**: the time for the team to complete the double-check task from receipt of order form until they report their findings to the test director.
- **Task flow**: observed handling and use of the order form, flow sheet, and pump.
- **Susceptibility to problems, errors, or deviation from process**: observed deviations from the process as described in participant instructions or problems encountered during the process.
- **Ability to catch pre-set programming errors**.
- **Nurses' preferences and perceptions**: determined from post-test briefing and questionnaire.

RESULTS

Task Time

Average time (expressed as hours:minutes:seconds) across all trials was 00:01:08 (standard deviation 00:00:26) (Tables 1 and 2). On average, the teams completed double-checks in a time of 00:01:15 using the flow sheet method and 00:01:02 using the read-back method. Because of scheduling problems, team 2 was asked to omit completion of the flow sheet during the read-back method, but even when the data for read-back trials from that team were discarded, the mean task time remained relatively unchanged (01:01).

Table 1. Time to complete double-checking (measured from the time the team received an order form to the time the double-check was completed).

Team no.	Method	Trial no.	Start time	Stop time	Time on task
Team 1	flow sheet	1	9:52:38	9:54:30	0:01:52
	flow sheet	2	9:55:09	9:56:23	0:01:14
	flow sheet	3	9:59:07	10:00:36	0:01:29
	flow sheet	4	10:02:06	10:03:24	0:01:18
	flow sheet	5	10:04:09	10:05:26	0:01:17
	flow sheet	6	10:07:29	10:08:19	0:00:50
	read back	7	10:12:03	10:13:29	0:01:26
	read back	8	10:17:21	10:19:16	0:01:55
	read back	9	10:19:51	10:21:03	0:01:12
	read back	10	10:22:05	10:22:48	0:00:43
	read back	11	10:23:39	10:24:39	0:01:00
	read back	12	10:26:06	10:27:03	0:00:57
Team 2	read back	1	10:56:25	10:57:40	0:01:15
	read back	2	11:01:15	11:02:01	0:00:46
	read back	3	11:03:55	11:05:05	0:01:10
	read back	4	11:06:14	11:07:18	0:01:04
	read back	5	11:08:31	11:09:42	0:01:11
	read back	6	11:10:24	11:11:24	0:01:00
	flow sheet	7	11:15:34	11:17:28	0:01:54
	flow sheet	8	11:18:56	11:19:58	0:01:02
	flow sheet	9	11:20:42	11:21:58	0:01:16
	flow sheet	10	11:23:08	11:25:06	0:01:58
	flow sheet	11	11:25:39	11:27:23	0:01:44
	flow sheet	12	11:27:58	11:29:59	0:02:01
Team 3	flow sheet	1	11:38:00	11:38:51	0:00:51
	flow sheet	2	11:39:26	11:40:21	0:00:55
	flow sheet	3	11:41:24	11:42:20	0:00:56
	flow sheet	4	11:42:57	11:43:45	0:00:48

Team no.	Method	Trial no.	Start time	Stop time	Time on task
Team 3	flow sheet	5	11:44:19	11:45:24	0:01:05
	flow sheet	6	11:46:23	11:46:59	0:00:36
	read back	7	11:50:36	11:51:26	0:00:50
	read back	8	11:51:53	11:52:37	0:00:44
	read back	9	11:53:03	11:53:49	0:00:46
	read back	10	11:54:15	11:54:48	0:00:33
	read back	11	11:55:36	11:56:31	0:00:55
	read back	12	11:57:01	11:57:52	0:00:51
Team 4	read back	1	12:14:40	12:16:27	0:01:47
	read back	2	12:17:16	12:18:15	0:00:59
	read back	3	12:18:34	12:19:40	0:01:06
	read back	4	12:20:21	12:21:11	0:00:50
	read back	5	12:21:42	12:22:32	0:00:50
	read back	6	12:22:42	12:23:28	0:00:46
	flow sheet	7	12:27:28	12:28:27	0:00:59
	flow sheet	8	12:28:42	12:29:26	0:00:44
	flow sheet	9	12:29:35	12:31:50	0:02:15
	flow sheet	10	12:32:38	12:33:21	0:00:43
	flow sheet	11	12:33:32	12:35:04	0:01:32
	flow sheet	12	12:35:18	12:35:53	0:00:35

Table 2. Average time on task and standard deviation.

	Average	Standard deviation
Both methods	0:01:08	0:00:26
Flow sheet method	0:01:15	0:00:30
Read-back method	0:01:02	0:00:20
Read-back method without team 2	0:01:01	0:00:22

Task Flow

Diagrams of the task flow are presented in Figures 1 and 2, in which the expected task flow is denoted by black lines and boxes. Observed deviations are denoted by grey lines and boxes. Deviations and/or difficulties encountered are explained in the next section.

Figure 1. Diagram of observed task flow for flow sheet method (deviations denoted by grey lines and boxes).

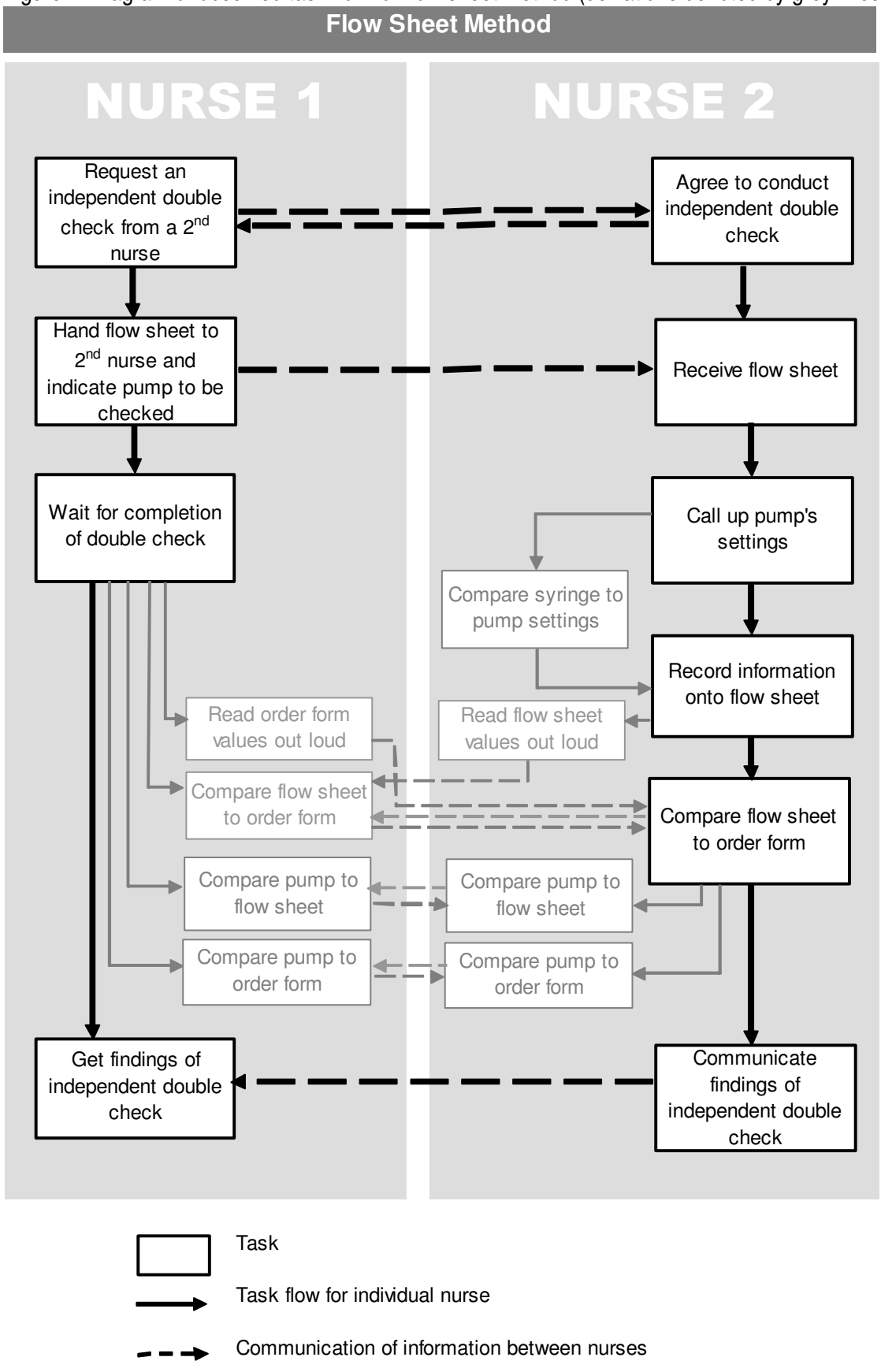
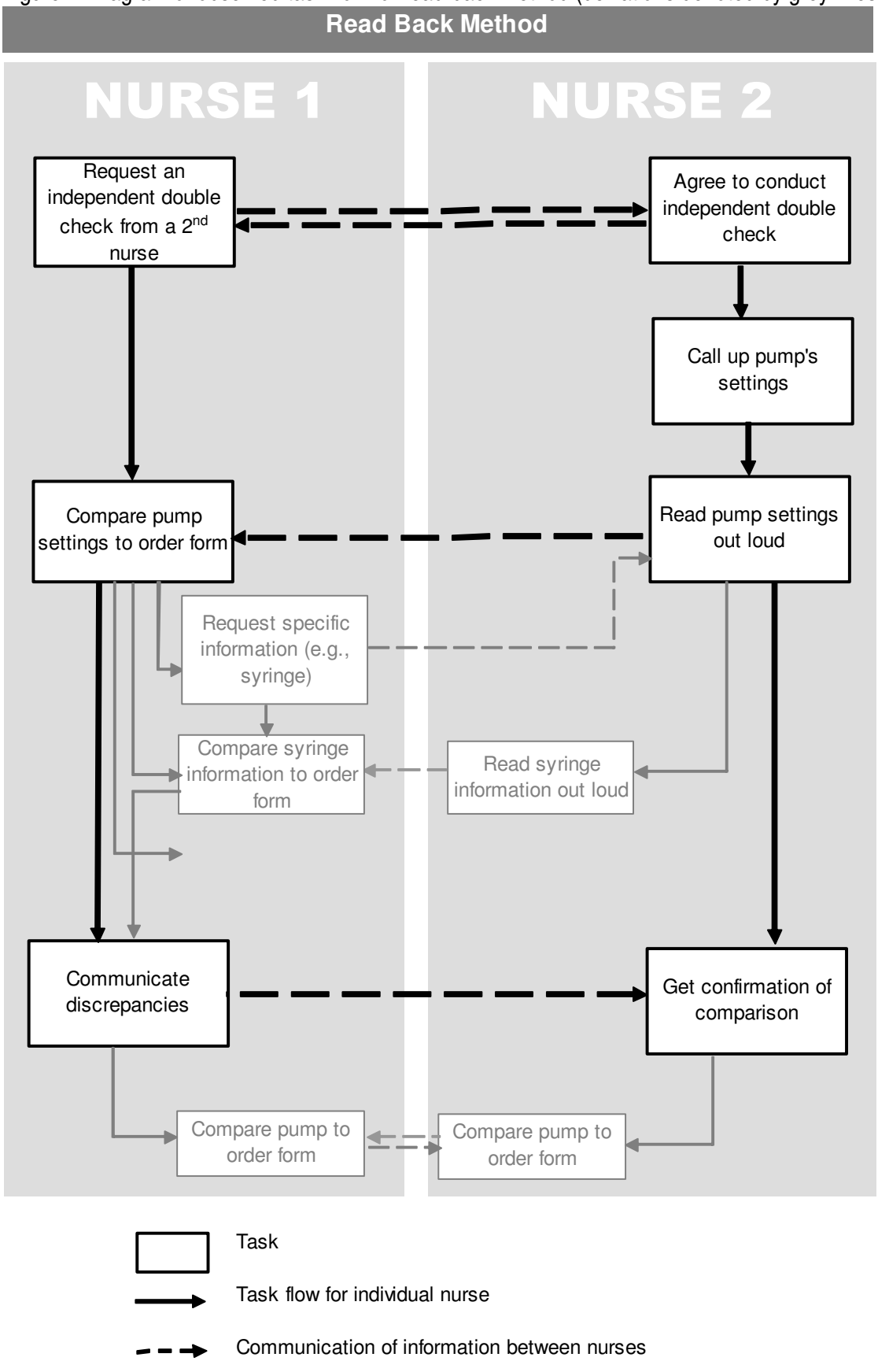


Figure 2. Diagram of observed task flow for read-back method (deviations denoted by grey lines and boxes).



Susceptibility to Problems, Errors, and Deviation from Process

Flow sheet Method:

In using the flow sheet method, nurses either read the settings out loud when comparing the flow sheet with the order form or conducted the comparison visually without communicating until they found a discrepancy. Even when they read the settings out loud, nurses tended to look over their team member's shoulder to see what was written on the other form. These variations are summarized below:

Teams performed the comparison of flow sheet to order form in a variety of ways:

1. Nurse 2 read the flow sheet values out loud while nurse 1 compared the values to the order form.
2. Nurse 1 read the order form values out loud while nurse 2 compared the values to the flow sheet.
3. The nurses read over each other's shoulder as they performed option 1 or 2.
4. Nurses 1 and 2 compared the order form with the flow sheet without speaking until they found a discrepancy.

When a discrepancy was found, nurses compared the pump readings to the flow sheet to make sure that a transcription error had not occurred or directly compared the pump settings with the order form.

Read-Back Method:

The pump does not specify the drug name on the settings review screen, so if the read-back was done by looking only at the screen, there was a possibility of failing to detect that an incorrect cassette had been inserted.

During read-back, it was noted that nurses had a tendency to look at both sources of information (the order form and the pump).

In one case, the nurse reading out values from the pump misread "conc" as continuous rate and the number value, even though the units (mg/ml) appeared next to the number value. The nurse checking the order form corrected this error.

Ability to catch pre-set programming errors

The 2 methods were equally effective for finding the deliberate programming errors. Overall, 28 (88%) of 32 errors were found. All of the 4 undetected errors were concentration errors. In 3 of these 4 concentration errors, the teams did not discover that the pump was set to dispense in micrograms. Only one team found all of the programming errors through their double-checks.

The pre-set programming errors are listed in Appendix H. Table 3 provides details on the errors and the teams' findings (which, if any, programming errors the teams found through their independent double-checks). Table 4 summarizes the total number of pre-set errors and the number found. Table 5 lists the errors that went undetected.

Table 3. Pre-set (deliberate) programming errors and team findings

Team no.	Trial no.	Deliberate error	Team findings	Notes
1	1	wrong conc	wrong conc	Nurse 2 misread “conc” as "continuous"; corrected by nurse 1
1	2	none	no error	
1	3	wrong cassette	wrong cassette	
1	4	micrograms	micrograms	
1	5	wrong conc	wrong conc	
1	6	none	no error	
1	7	wrong conc	wrong conc	
1	8	micrograms	micrograms	
1	9	none	no error	
1	10	none	no error	
1	11	wrong cassette	wrong cassette	
1	12	wrong conc	wrong conc	
2	1	**wrong conc**	**no error**	**did not find error**
2	2	**micrograms**	**no error**	**did not find error**
2	3	inadvertent error	wrong 4 hr limit	order form had incorrect 4 hour limit (NOT COUNTED)
2	4	none	no error	
2	5	wrong cassette	wrong cassette	
2	6	wrong conc	wrong conc	
2	7	wrong conc	wrong conc	
2	8	none	no error	
2	9	wrong cassette	wrong cassette	
2	10	micrograms	micrograms	
2	11	wrong conc	wrong conc	
2	12	none	no error	
3	1	wrong conc	wrong conc	
3	2	none	no error	
3	3	wrong cassette	wrong cassette	
3	4	**micrograms**	**no error**	**did not find error**
3	5	wrong conc	wrong conc	
3	6	none	no error	
3	7	wrong conc	wrong conc	
3	8	micrograms	micrograms	
3	9	none	no error	
3	10	none	no error	
3	11	wrong cassette	wrong cassette	
3	12	wrong conc	wrong conc	
4	1	wrong conc	wrong conc	
4	2	micrograms	wrong conc	
4	3	inadvertent error	wrong 4 hr limit	order form had incorrect 4 hour limit (NOT COUNTED)
4	4	none	no error	
4	5	wrong cassette	wrong cassette	
4	6	wrong conc	wrong conc	
4	7	wrong conc	wrong conc	
4	8	none	no error	
4	9	wrong cassette	wrong cassette	
4	10	**micrograms**	**no error**	**did not find error**
4	11	wrong conc	wrong cassette	
4	12	none	no error	

Table 4. Number of deliberate errors found

	No. of errors detected	No. of errors present	% errors found
Flow sheet method	14	16	88
Read-back method	14	16	88
Total	28	32	88

Table 5. Errors that went undetected

	No. of errors undetected	Type of programming Error	Description of error
Flow sheet method	2	Incorrect concentration	10 mg/ml was ordered, but programmed as 2 mg/ml
		Micrograms	Meperidine 10 mg/ml was programmed using micrograms
Read-back method	2	Micrograms	Morphine 2 mg/ml was programmed using micrograms
		Micrograms	Morphine 2 mg/ml was programmed using micrograms

Nurses' Preferences and Perceptions

Most participants (7 of 8) preferred the read-back method, although 3 participants thought that the flow sheet method might be more effective in catching errors. Most nurses also felt that the read-back method was quicker to perform, easier to hand off to a second nurse, and more likely to be done (if nurses had a choice). All nurses felt that the read-back method would be effective in catching a majority of errors, whereas there was less agreement on the level of effectiveness of the flow sheet method. Finally, 6 of the 8 nurses felt that the read-back method represented very little extra work, whereas only 2 of the 8 felt that the flow sheet was very little extra work. The following table summarize the responses for each of the post-test questionnaire questions (see Appendix G).

Table 6. Questionnaire responses.

Question	No. of respondents (n = 8)		
	Flow sheet	Read-back	About the same
If you had to pick one, which method of double-checking do you prefer?	0	7*	NA
Circle the method that you think is better for each of the following.			
Easier to carry out	0	4	4
Quicker to carry out	0	7	1
Easier to learn	0	4	4
Easier to hand off to second nurse	0	6	2
More effective (more likely to catch errors)	3	4	1
More likely to be done (if nurses had a choice)	1	6	1
More likely to be done correctly by both nurses	2	4	2

Question	No. of respondents (n = 8)		
	Flow sheet	Read-back	About the same
How effective do you think the 2 methods are for conducting double-checks?			
Won't catch any errors	1	0	0
Will catch only a few errors	2	0	0
Will catch about half of the errors	1	0	0
Will catch a majority of errors	4	8	0
How much work do you think the 2 methods of double-checking add?			
Very little extra work	2	6	0
Somewhat more work	5	0	0
Seems like a lot more work	0	1	0
Depends on the situation	1	1	0

* One participant did not respond to this question on the written questionnaire, but indicated verbally during the post-test briefing that she preferred the flow sheet method.

DISCUSSION

Nurses expressed reluctance to hand off monitoring forms for another nurse to fill out, as was required by the flow sheet method. They felt responsible for the forms and were uncomfortable delegating that responsibility to someone else. Another reason for this reluctance was the sense that in asking for a double-check, they were in effect asking another nurse for a favour and therefore felt that they should participate in the double-check (i.e., the double-check should be conducted *together*).

Design implication: ***Develop tools to guide double-checks that are done 'together' in addition to those done independently.***

Design implication: ***Ensure that the process does not require handing off forms to a second person.***

With both methods, the nurses demonstrated a natural tendency to look for visual confirmation. That is, upon hearing an incorrect setting, they immediately wanted visual confirmation of the discrepancy. Thus, with the read-back method, the teams tended to look at both the pump and the order form as they performed the check. With the flow sheet method, when a discrepancy was found between the order form and the flow sheet, the nurse had the added task of comparing the flow sheet with the pump and/or the pump with the order form to determine whether an error had been made in transcribing the settings onto the flow sheet or if there had been a programming error. This extra task made the double-check process unnecessarily complex and consumed the valuable time of both nurses as they resolved the discrepancy.

Design implication: ***Avoid requiring nurses to consider a third source of information.***

When using the flow sheet method, participants sometime verbalized what they were reading. This occurred in a bi-directional fashion: either nurse 1 would read from the order form or nurse 2 would read from the flow sheet. With the read-back method, this bi-directionality did not occur as much, because the teams were instructed to read directly from the pump. It is not clear whether this happens in the field. In either case, it is important that the sequence of information on the order form and flow sheet be as consistent as possible with the sequence of information on the pump. The terminology used should also be consistent.

Design implication: ***Ensure consistency (in information sequence and terminology) between the pump, order form, and flow sheet.***

With the read-back method, there are few reminders for nurses to look at the cassette. Although the nurses learned to do this, there were still instances during the usability test when they needed to be reminded by their teammates to look at the cassette.

Design implication: ***Provide a specific prompt to look at the cassette***

With both the read-back and flow sheet methods, the nurses were so focused in on verifying the *numbers* that they sometimes forgot to check the units used for programming the settings. This is a particularly troublesome issue with the Abbott Lifecare 4100 PCA Plus pump, because it can be set in either micrograms or milligrams.

Design implication: ***Provide a specific prompt to look at units (e.g., micrograms or milligrams)***

As some nurses commented, a shorthand method is sometimes used to check pumps. For instance, 2-1-5-40 means 2 mg/ml concentration, 1 mg dose, 5 minute lockout, and 4 hour limit of 40 mg. This is an effective way to manage valuable working memory resources. However, this shorthand focuses only on the numbers and not other crucial information such as drug name or units.

***Design implication:* Lay out the order form to promote strategies that reduce cognitive load.**

RECOMMENDATIONS

The design implications identified above should be incorporated into modifications of the double-check processes described in this report. The use of a checklist may be one way of doing so. However, a checklist must be designed with human factors considerations, so that it encourages appropriate or more effective double-checking. Otherwise, the checklist itself may become a source of error or confusion. In designing an appropriate and effective checklist it is important to answer the following questions: Which behaviours are you trying to guide? How specific should the checklist be? For instance, a checklist that lists "drug concentration" may not catch drug syringe errors if the person looks only at the pump's programmed settings. In what order should checklist items appear on the checklist? What terminology is most effective and understandable? How should items be grouped? Answers to some of these questions can be found through usability testing and/or human factors principles. Accordingly, the recommendations below are derived from the results of this usability test, along with human factors research on the design of cockpit checklists in aviation. [1]

1. **If using a read-back format for conducting an independent double-check, the read-back process should be guided by a list of variables to be checked (e.g., a checklist).** The checklist should use specific terminology to guide the nurse to look at specific settings (syringe, units), rather than more generic terminology (e.g., "drug concentration"), when information about the setting can be found in more than one place (e.g., concentration is verified by looking at the syringe as well as the programmed value and programmed units).

2. **The checklist should be embedded in the order form.** If the checklist is presented as a separate sheet, it takes more effort to remember to use it and will be more difficult to follow (since it will be considered another source of information that the nurses must consult, beyond the pump and the order form). The shifting of visual focus from one source of information to another requires some mental workload (working memory). Appropriate placement and formatting of the checklist should minimize the requirement to shift visual focus.

3. **The checklist should be organized in a way that is familiar to nurses, and should promote strategies for reducing cognitive load (e.g., by incorporating shortcuts for expert users).** The ordered values should be aligned so as to minimize visual searching. There should be an obvious visual link to the checklist, so that it naturally guides readers as they shift back and forth between the checklist and the order form.

4. **The order of items in the checklist should correspond to the order in which items appear on the pump or the order form**. Ideally, the order of items on the order form should match the order of items on the pump screen. Also, checklist items should be grouped by the geographic location where the items are found (in the case of PCA pumps, by syringe and by programmed settings).

5. **Little or no training should be required to use the checklist.** A checklist represents a visual reminder to carry out specific activities or tasks. As such, it should be intuitive and self-explanatory. Any checklist that requires extensive training or explanations as to its meaning or interpretation is poorly designed and may add to the

[1] Degani A & Wiener EL. (1993). Cockpit Checklists: Concepts, Design, and Use. *Human Factors*, 35, 345-359

already heavy cognitive load of nurses. For instance, if the checklist lists "concentration", and nurse managers feel it is necessary to remind their staff members that they should look at the cassette as well as the pump settings when checking this item, then the checklist has failed as a visual reminder, because it does not relieve working memory.

6. **The checklist should be explicit in terms of the manner in which it is read out and in which the response is made**. This can be accomplished through appropriate wording on the checklist and can be reinforced through training. For instance, in aviation, "check xyz" is considered ambiguous in terms of the expectations of the responder ("yes" means checked? Or "yes" means correct?). A more appropriate item would read "What is the reading on xyz?" to which the responder is expected to report a value (e.g., "xyz is 124").

7. **In general, the most critical items on the checklist should appear as close to the beginning of the list as possible**. In some cases, this recommendation may conflict with recommendations 3 and 4 but should take precedence over them. In the case of PCA pumps, there is no conflict. Errors in setting drug concentration or putting in the wrong syringe have cascading effects (an incorrect concentration will render all other settings incorrect, since the pump calculates how much drug to deliver according to the drug concentration); this item should therefore appear near the beginning of the list.

8. **The final item on the checklist should represent completion of the checklist (for instance, signature by the responsible staff member).** This step allows practitioners to acknowledge completion before moving on to other activities and serves as a record of completion.

LIMITATIONS

- *This was a single task study*. No other tasks were involved and the nurses could therefore focus on one task. A more accurate representation of the workplace environment would involve giving participants several tasks, including double-checking a pump, so as to avoid focus on just double-checking of pumps.
- *There were no interruptions and few distractions*. With the exception of beeping from the pumps being programmed behind a wall, there were few other noises or distractions.
- *There was no time pressure*. Nurses were instructed to conduct the checks at a comfortable pace and were not asked to perform as fast as possible.
- *Participants had enhanced objectivity.* Because participants did not program the pumps, they could be more objective. As a result, the test situation may not accurately represent the bias that might occur in practice.
- *Limitations of the read-back method were not explored*. Although not observed in this usability test (because of the nature of the ordered values and the pump involved), the read-back method is susceptible to variations that may compromise effectiveness, for instance, reading out each digit ("one five" rather than "fifteen"), using a shorthand form (e.g., "2-5-6-30" rather than "concentration 2 mg/ml, 5 mg dose, 6 minute lockout, 4 hour limit of 30 mg"), or when reading a range such as "one to two" (e.g., 1 – 2 mg/ml) it might be misunderstood as "122 mg/ml").

ACKNOWLEDGEMENTS

The usability test described in this report could not have been completed without the time and commitment of many people. The following people played significant roles in ensuring the success of the usability test: Linda Turner, Margaret Colquhoun, Christine Koczamara, Julie Greenall, Carol, Simone, and Sylvia Hyland. In addition, the assistance of the staff at the 2 large teaching hospitals was greatly appreciated.

APPENDICES

APPENDIX A: TEAM PACKAGES

Each TEAM PACKAGE contains:

- ❒ Team number and order of methods (flow sheet first or read-back first)
- ❒ PCA pump settings for each trial
- ❒ Introduction
- ❒ Instructions (according to team number and order of methods)
- ❒ Practice order sheet (filled in)
- ❒ Practice flow sheet (blank)
- ❒ 12 order forms (filled in and stamped with and ordered by trial number)
- ❒ 12 flow sheets (blank, stamped with trial number)
- ❒ 12 sets of settings to program the pump (in order of trial)
- ❒ Post-test briefing questions
- ❒ 2 questionnaires
- ❒ Observation sheet with start time and stop time

APPENDIX B: PROTOCOL

Teams 1 and 3: Flow sheet method first

❒ **Introduction / Pre–Brief**

❒ **Team receives instruction on flow sheet method**

❒ Team practises the method using pump 1 (programmed with morphine 2 mg/ml, PCA mode, 5 mg dose, 8 minute lockout, 4 hour limit of 35 mg)

Team performs trials 1–3
- ❒ Trial 1 – pump 1
- ❒ Trial 2 – pump 2
- ❒ Trial 3 – pump 1

Team members switch roles and perform trials 4–6
- ❒ Trial 4 – pump 2
- ❒ Trial 5 – pump 1
- ❒ Trial 6 – pump 2

❒ **Team receives instruction on read-back method**

❒ Team practises the method using pump 2 (programmed with morphine 2 mg/ml, PCA mode, 5 mg dose, 8 minute lockout, 4 hour limit of 35 mg)

Team performs trials 7–9
- ❒ Trial 7 – pump 1
- ❒ Trial 8 – pump 2
- ❒ Trial 9 – pump 1

Team members switch roles and perform trials 10–12
- ❒ Trial 10 – pump 2
- ❒ Trial 11 – pump 1
- ❒ Trial 12 – pump 2

❒ Team members are asked post-test briefing questions
❒ Team members fill out questionnaire

APPENDIX B: PROTOCOL

Teams 2 and 4: Read-back method first

❒ **Introduction / Pre–Brief**

❒ **Team receives instruction on read-back method**

❒ Team practises the method using pump 1 (programmed with morphine 2 mg/ml, PCA mode, 5 mg dose, 8 minute lockout, 4 hour limit of 35 mg)

Team performs trials 1–3
- ❒ Trial 1 – pump 1
- ❒ Trial 2 – pump 2
- ❒ Trial 3 – pump 1

Team members switch roles and perform trials 4–6
- ❒ Trial 4 – pump 2
- ❒ Trial 5 – pump 1
- ❒ Trial 6 – pump 2

❒ **Team receives instruction on flow sheet method**

❒ Team practises the method using pump 2 (programmed with morphine 2 mg/ml, PCA mode, 5 mg dose, 8 minute lockout, 4 hour limit of 35 mg)

Team performs trials 7–9
- ❒ Trial 7 – pump 1
- ❒ Trial 8 – pump 2
- ❒ Trial 9 – pump 1

Team members switch roles and perform trials 10–12
- ❒ Trial 10 – pump 2
- ❒ Trial 11 – pump 1
- ❒ Trial 12 – pump 2

❒ Team members are asked post-test briefing questions
❒ Team members fill out questionnaire

APPENDIX C: SCRIPT FOR INTRODUCTION (all teams)

Introduction / Pre-Brief (*director reads this script)*

Thanks for coming today. My name is […], and this is […], who is helping me today. We are conducting a study on independent double-checks, and we've asked you to come today to get your feedback. What we are doing is we're exploring two different methods of double-checking to see how easy or difficult they are to do, and if one method is better than the other. So we are not evaluating the two of you. Even though we are going to be keeping track of what you do and how long it takes, it's to give us an idea of how long it *typically* takes, *not how fast you can do it*, and also whether there are any problems associated with these methods. So what we'll be doing next is I'll explain the 2 different methods of double-checking and then I am going to ask you to do a series of double-checks on some PCA pumps so that we can observe the process. Do you have any questions at this point?

APPENDIX D: INSTRUCTION SCRIPT (all teams)

Instructions for Participants *(director reads this script)*

Teams 1, 3: Flow sheet method first

Flow sheet method

The first method of double-checking we call the flow sheet method, because you use the flow sheet to help check the settings. Often, the nurse who programs the pump fills out the flow sheet. But in this method, instead of filling out the flow sheet, you give it to a second nurse who will fill it out as they double-check the pump. As the second nurse, you would look up the pump settings and writes them down on the flow sheet. Then, you both compare the flow sheet to the order form to make sure they match.

So let's just walk through it together before you do it on your own. You'll be working as a team. One of you will be nurse 1, while the other is nurse 2 to start with, then you'll switch roles. To start with, you are nurse 1. I'll hand you an order form and flow sheet. This is the pump you've just programmed (it's already programmed for you). Go ahead and hand the flow sheet to nurse 2 and ask her to double-check the settings. Nurse 2 you have to call up the settings on the pump. Go ahead and do that, and write down the settings from the pump onto the flow sheet. When you are done, you should both check to make sure the flow sheet matches the order sheet. Then tell me whether the pump is set correctly. Go ahead and give that a try.

Do both of you feel ready to do a few double-checks? I want you to carry this out as if you were actually doing this on the job. In other words, go at a pace that you're comfortable with.

Ok, I'll be giving you 6 order forms. Here is the first one. Go ahead and carry out a double-check.

[do 3 trials then switch roles (nurse 1 and nurse 2)]

Next you are going to switch roles. You are nurse 1 now and you are nurse 2.

[do 3 trials]

Read-back method

We're going to try another method of double-checking now. The second method is called read-back. In this method, when you ask a second nurse to double-check the pump, they look up the pump settings and read them out to you, and you check it against the order form.

So let's just walk through it together before you do it on your own. You'll be working as a team again. To start with, you are nurse 1. I'll hand you an order form and flow sheet. This is the pump you've just programmed (it's already programmed for you). Go ahead and fill out the flow sheet based on the order form. Next, ask nurse 2 to double-check the settings. Nurse 2 you have to call up the settings on the pump. Then you will read out the settings from the pump so that nurse 1 can check it against the order form. Then tell me whether the pump is set correctly. Go ahead and give that a try.

Do both of you feel ready to do a few more double-checks? Again, I want you to carry this out as if you were actually doing this on the job. In other words, go at a pace that you're comfortable with.

Ok, here is the first of 6 more order forms.

[do 3 trials then switch roles (nurse 1 and nurse 2)]

Next you are going to switch roles. You are nurse 1 now and you are nurse 2.

[do 3 trials]

Teams 2, 4: Read-back method first

Read-back method

The first method of double-checking is called read-back. In this method, when you ask a second nurse to double-check the pump, they look up the pump settings and read them out to you, and you check it against the order form.

So let's just walk through it together before you do it on your own. You'll be working as a team. One of you will be nurse 1, while the other is nurse 2 to start with, then you'll switch roles. To start with, you are nurse 1. I'll hand you an order form and flow sheet. This is the pump you've just programmed (it's already programmed for you). Go ahead and fill out the flow sheet based on the order form. Next, ask nurse 2 to double-check the settings. Nurse 2 you have to call up the settings on the pump. Then you will read out the settings from the pump so that nurse 1 can check it against the order form. Then tell me whether the pump is set correctly. Go ahead and give that a try.

Do both of you feel ready to do a few double-checks? I want you to carry this out as if you were actually doing this on the job. In other words, go at a pace that you're comfortable with.

Ok, I'll be giving you 6 order forms. Here is the first one. Go ahead and carry out a double-check.

[do 3 trials then switch roles (nurse 1 and nurse 2)]

Next you are going to switch roles. You are nurse 1 now and you are nurse 2.

[do 3 trials]

Flow sheet method

We're going to try another method of double-checking now. The second method we call the flow sheet method, because you use the flow sheet to help check the settings. Often, the nurse who programs the pump, fills out the flow sheet. But in this method, instead of filling out the flow sheet, you give it to a second nurse who will fill it out as they double-check the pump. The second nurse calls up the pump settings and writes the settings down on the flow sheet. Then, you both compare the flow sheet to the order form to make sure they match.

So let's just walk through it together before you do it on your own. You'll be working as a team again. To start with, you are nurse 1. I'll hand you an order form and flow sheet. This is the pump you've just programmed (it's already programmed for you). Go ahead and hand the flow sheet to nurse 2 and ask her to double-check the settings. Nurse 2 you have to call up the settings on the pump. Go ahead and do that, and write down the settings from the pump onto the flow sheet. When you are done, you should both check to make sure the flow sheet matches the order sheet. Then tell me whether the pump is set correctly. Go ahead and give that a try.

Do both of you feel ready to do a few double-checks on your own? Again, I want you to carry this out as if you were actually doing this on the job. In other words, go at a pace that you're comfortable with.

Ok, here is the first of 6 more order forms ….

[do 3 trials then switch roles (nurse 1 and nurse 2)]

Next you are going to switch roles. You are nurse 1 now and you are nurse 2.

[do 3 trials]

APPENDIX E: OBSERVATION SHEETS

Observation Sheet

TEAM # : **1**

METHOD: **Flow Sheet**

Team Report:

Trial 1

Start time: _____ (when Laura hands PCA order form to Nurse 1)

Stop time: _____ (after team reports whether the pump is set correctly) ⟹

Trial 2

Start time: _____ (when Laura hands PCA order form to Nurse 1)

Stop time: _____ (after team reports whether the pump is set correctly) ⟹

Trial 3

Start time: _____ (when Laura hands PCA order form to Nurse 1)

Stop time: _____ (after team reports whether the pump is set correctly) ⟹

Trial 4

Start time: _____ (when Laura hands PCA order form to Nurse 1)

Stop time: _____ (after team reports whether the pump is set correctly) ⟹

Trial 5

Start time: _____ (when Laura hands PCA order form to Nurse 1)

Stop time: _____ (after team reports whether the pump is set correctly) ⟹

Trial 6

Start time: _____ (when Laura hands PCA order form to Nurse 1)

⟹

Stop time: ☐ (after team reports whether the pump is set correctly)

APPENDIX E: OBSERVATION SHEETS

Observation Sheet

TEAM # :

METHOD: Read-back

Team Report :

Trial 7

Start time: ☐ (when Laura hands PCA order form to Nurse 1)

Stop time: ☐ (after team reports whether the pump is set correctly) ⟹ ☐

Trial 8

Start time: ☐ (when Laura hands PCA order form to Nurse 1)

Stop time: ☐ (after team reports whether the pump is set correctly) ⟹ ☐

Trial 9

Start time: ☐ (when Laura hands PCA order form to Nurse 1)

Stop time: ☐ (after team reports whether the pump is set correctly) ⟹ ☐

Trial 10

Start time: ☐ (when Laura hands PCA order form to Nurse 1)

Stop time: ☐ (after team reports whether the pump is set correctly) ⟹ ☐

Trial 11

Start time: ☐ (when Laura hands PCA order form to Nurse 1)

Stop time: ☐ (after team reports whether the pump is set correctly) ⟹ ☐

Trial 12

Start time: ☐ (when Laura hands PCA order form to Nurse 1) ☐

Stop time: [ ] (after team reports whether the pump is set correctly) ⟹

APPENDIX F: POST-TEST BRIEFING QUESTIONS

Post-Test Briefing *(Directors reads these questions to participants)*

That's all the double-checks you're going to do. Now I'd like to ask you a few questions about the 2 methods that you tried.

First, which method did you prefer? flow sheet read-back
(circle one for each team member)
flow sheet read-back

What do you like about that method?

If you were in a hurry and were asked to do a double-check, which method are you more likely use? Why? (Circle one for each team member)

(a) flow sheet or (b) read-back

(a) flow sheet or (b) read-back

If you were doing the double-check at night (patient is sleeping, room is dark), which method are you more likely use? Why? (Circle one for each team member)

(a) flow sheet or (b) read-back

(a) flow sheet or (b) read-back

Can you think of any other situations that might make it difficult to use either method of double-checking?

What do you think would prevent you from carrying out an independent double-check? (for example: finding a 2nd nurse that's free and willing, feeling reluctant to ask another nurse to do it, other nurses' perception of you, noisy environment, patient is sleeping)

Is there anything that you felt was difficult or awkward about the flow sheet method? (for example, remembering to use the flow sheet, handing it off to someone, writing down the settings)

Is there anything that you felt was difficult or awkward about the read-back method? (for example, having to wait around for someone to read it off to you, or ?)

Can you think of anything that you would change or modify in either method to make it easier or more efficient? (For example, would any changes to the order form or flow sheet make it easier? Specific training that should go along with it?)

Can you suggest changes for the order form or flow sheet that would make it easier to use for a double-check?

APPENDIX G: POST-TEST QUESTIONNAIRE (filled in by participants)

If you had to pick one, which method of double-checking do you prefer? (circle one)

(a) flow sheet or (b) read-back

Circle the method that you think is better for each of the following: (circle one)

Easier to carry out	(a) flow sheet	(b) read-back	(c) about the same
Quicker to carry out	(a) flow sheet	(b) read-back	(c) about the same
Easier to learn	(a) flow sheet	(b) read-back	(c) about the same
Easier to hand off to 2nd nurse	(a) flow sheet	(b) read-back	(c) about the same
More effective (more likely to catch errors)	(a) flow sheet	(b) read-back	(c) about the same
More likely to be done (if nurses had a choice)	(a) flow sheet	(b) read-back	(c) about the same
More likely to be done correctly by both nurses	(a) flow sheet	(b) read-back	(c) about the same

How effective do you think the 2 methods are for conducting double-checks?

Flow sheet method (circle one)

(a) won't catch any errors
(b) will catch only a few errors
(c) will catch about half of the errors
(d) will catch a majority of errors

Comments:

Read-back method (circle one)

(a) won't catch any errors
(b) will catch only a few errors
(c) will catch about half of the errors
(d) will catch a majority of errors

Comments:

Team 1

How much work do you think the 2 methods of double-checking add?

Flow sheet method (circle one)

(a) Very little extra work
(b) Somewhat more work
(b) Seems like a lot more work
(d) Depends on the situation (explain what situations it would be too much work)

Explanation or comments:

Read-back method (circle one)

(a) Very little extra work
(b) Somewhat more work
(b) Seems like a lot more work
(d) Depends on the situation (explain what situations it would be too much work)

Explanation or comments:

Any other comments?

APPENDIX H: ORDER FORM AND PUMP SETTINGS FOR TEAMS 1 AND 3

Flow Sheet Method

1

ORDER FORM	ACTUAL
Morphine	Morphine 2 mg/ml syringe
2 mg/ml	1 mg/ml
PCA mode	
0.5–1 mg	1 mg
6 minutes	6 minutes
30 mg	30 mg

2

ORDER FORM	ACTUAL
Meperidine	Meperidine 10 mg/ml
10 mg/ml	10 mg/ml
PCA mode	
10–20 mg	10 mg
10 minutes	10 minutes
50 mg	50 mg

3

ORDER FORM	ACTUAL
Hydromorphone	Morphine 2 mg/ml syringe
0.4 mg/ml	0.4 mg/ml
PCA mode	PCA mode
0.2–0.3mg	0.2 mg
7 minutes	7 minutes
10 mg	6 mg

4

ORDER FORM	ACTUAL
Morphine	Morphine 2 mg/ml syringe
2 mg/ml	2 **µg**/ml
PCA mode	
1–2 mg	2 µg
5 minutes	5 minutes
50 mg	50 µg

5

ORDER FORM	ACTUAL
Hydromorphone	Hydromorphone 0.4 mg/ml syringe
0.4 mg/ml	4 mg/ml
PCA mode	
0.3-0.6 mg	0.4 mg
6 minutes	6 minutes
30 mg	30 mg

6

ORDER FORM	ACTUAL
Meperidine	Meperidine 10mg/ml syringe
10 mg/ml	10 mg/ml
PCA mode	
10-20 mg	20 mg
10 minutes	10 minutes
50 mg	50 mg

7

ORDER FORM	ACTUAL
Morphine	Morphine 10 mg/ml syringe
10 mg/ml	2 mg/ml
PCA mode	
0.5–1 mg	1 mg
6 minutes	6 minutes
30 mg	30 mg

8

ORDER FORM	ACTUAL
Meperidine	Meperidine 10 mg/ml syringe
10 mg/ml	10 **µg**/ml
PCA mode	
10–20 mg	10 µg
10 minutes	10 minutes
50 mg	50 µg

9

ORDER FORM	ACTUAL
Hydromorphone	Hydromorphone
0.4 mg/ml	0.4 mg/ml
PCA mode	
0.2–0.3 mg	0.3 mg
7 minutes	7 minutes
10 mg	10 mg

10

ORDER FORM	ACTUAL
Morphine	Morphine 2 mg/ml syringe
2 mg/ml	2 mg/ml
PCA mode	
1–2 mg	1 mg
5 minutes	5 minutes
50 mg	50 mg

11

ORDER FORM	ACTUAL
Hydromorphone	Morphine 2 mg/ml syringe
0.4mg/ml	0.4 mg/ml
PCA mode	
0.3–0.6 mg	0.4 mg
6 minutes	6 minutes
30 mg	12 mg

12

ORDER FORM	ACTUAL
Meperidine	Meperidine 10mg/ml syringe
10mg/ml	5 mg/ml
PCA mode	
10–20 mg	15 mg
10 minutes	10 minutes
50 mg	50 mg

Verbal Read-Back Method

APPENDIX H: ORDER FORM AND PUMP SETTINGS FOR TEAMS 2, 4

VERBAL READ-BACK METHOD

1

ORDER FORM	ACTUAL
Morphine	Morphine 10 mg/ml syringe
10 mg/ml	2 mg/ml
PCA mode	
0.5–1 mg	1 mg
6 minutes	6 minutes
30 mg	30 mg

2

ORDER FORM	ACTUAL
Meperidine	Meperidine 10
10 mg/ml	50 **µg**/ml
PCA mode	
10–20 mg	10 µg
10 minutes	10 minutes
50 mg	50 µg

3

ORDER FORM	ACTUAL
Hydromorphone	Hydromorphone 0.4 mg/ml syringe
0.4 mg/ml	0.4 mg/ml
PCA mode	
0.2–0.3 mg	0.3 mg
7 minutes	7 minutes
10 mg	10 mg

4

ORDER FORM	ACTUAL
Morphine	Morphine 2 mg/ml syringe
2 mg/ml	2 mg/ml
PCA mode	
1–2 mg	1 mg
5 minutes	5 minutes
50 mg	50 mg

5

ORDER FORM	ACTUAL
Hydromorphone	Morphine 2 mg/ml syringe
0.4 mg/ml	0.4 mg/ml
PCA mode	
0.3–0.6 mg	0.4 mg
6 minutes	6 minutes
30 mg	12 mg

6

ORDER FORM	ACTUAL
Meperidine	Meperidine 10
10 mg/ml	5 mg/ml
PCA mode	
10–20 mg	15 mg
10 minutes	10 minutes
50 mg	50 mg

FLOW SHEET METHOD

7

ORDER FORM	ACTUAL
Morphine	Morphine 2 mg/ml syringe
2 mg/ml	1 mg/ml
PCA mode	
0.5–1 mg	1mg
6 minutes	6 minutes
30 mg	30 mg

8

ORDER FORM	ACTUAL
Meperidine	Meperidine 10
10 mg/ml	10 mg/ml
PCA mode	
10–20mg	10 mg
10 minutes	10 minutes
50 mg	50 mg

9

ORDER FORM	ACTUAL
Hydromorphone	Morphine 2 mg/ml syringe
0.4 mg/ml	0.4 mg/ml
PCA mode	PCA mode
0.2–0.3mg	0.2 mg
7 minutes	7 minutes
10 mg	6 mg

10

ORDER FORM	ACTUAL
Morphine	Morphine 2 mg/ml syringe
2 mg/ml	2**µg**/ml
PCA mode	
1–2 mg	2 µg
5 minutes	5 minutes
50 mg	50 µg

11

ORDER FORM	ACTUAL
Hydromorphone	Hydromorphone 0.4 mg/ml syringe
0.4 mg/ml	4 mg/ml
PCA mode	
0.3–0.6 mg	0.4 mg
6 minutes	6 minutes
30 mg	30 mg

12

ORDER FORM	ACTUAL
Meperidine	Meperidine 10
10 mg/ml	10 mg/ml
PCA mode	
10–20 mg	20 mg
10 minutes	10 minutes
50 mg	50 mg

APPENDIX I: SETTINGS PROGRAMMED INTO PUMP

PCA SETTINGS: Flow Sheet Method

❒ TRIAL 1

Cassette:	**Morphine 2 mg/ml**
Concentration	**1 mg/ml**
Mode	PCA only
Dose	**1 mg**
Lockout	**6 minutes**
4 hour limit	**30 mg**

❒ TRIAL 2

Cassette:	**Meperidine 10 mg/ml**
Concentration	**10 mg/ml**
Mode	PCA only
Dose	**10 mg**
Lockout	**10 minutes**
4 hour limit	**50 mg**

❒ TRIAL 3

Cassette:	**Morphine 2 mg/ml**
Concentration	**0.4 mg/ml**
Mode	PCA only
Dose	**0.2 mg**
Lockout	**7 minutes**
4 hour limit	**6 mg**

❒ TRIAL 4

Cassette:	**Morphine 2 mg/ml**
Concentration	**2 µg/ml** *** ***micrograms*****
Mode	PCA only
Dose	**2 µg**
Lockout	**5 minutes**
4 hour limit	**50 µg**

❒ TRIAL 5

Cassette:	**Hydromorphone 0.4 mg/ml**
Concentration	**4 mg/ml**
Mode	PCA only
Dose	**0.4** mg
Lockout	**6 minutes**
4 hour limit	**30 mg**

❒ TRIAL 6

Cassette:	**Meperidine 10 mg/ml**
Concentration	**10 mg/ml**
Mode	PCA only
Dose	**20** mg
Lockout	**10 minutes**
4 hour limit	**50 mg**

APPENDIX I: SETTINGS PROGRAMMED INTO PUMP

PCA SETTINGS: Read-Back Method

❒ TRIAL 1

Cassette:	**Morphine 10 mg/ml**

Concentration	**2 mg/ml**
Mode	PCA only
Dose	**1 mg**
Lockout	**6 minutes**
4 hour limit	**30 mg**

❒ TRIAL 2

Cassette:	**Meperidine 10 mg/ml**

Concentration	**50 µg/ml**	*** ***micrograms*****
Mode	PCA only	
Dose	**10 µg**	
Lockout	**10 minutes**	
4 hour limit	**50 µg**	

❒ TRIAL 3

Cassette:	**Hydromorphone 0.4 mg/ml**

Concentration	**0.4 mg/ml**
Mode	PCA only
Dose	**0.3 mg**
Lockout	**7 minutes**
4 hour limit	**10 mg**

❒ TRIAL 4

Cassette:	**Morphine 2 mg/ml**

Concentration	**2 mg/mL**
Mode	PCA only
Dose	**1 mg**
Lockout	**5 minutes**
4 hour limit	**50 mg**

❒ TRIAL 5

Cassette:	**Morphine 2 mg/mL**

Concentration	**0.4 mg/ml**
Mode	PCA only
Dose	**0.4 mg**
Lockout	**6 minutes**
4 hour limit	**12 mg**

❒ TRIAL 6

Cassette:	**Meperidine 10 mg/ml**

Concentration	**5 mg/ml**
Mode	PCA only
Dose	**15 mg**
Lockout	**10 minutes**
4 hour limit	**50 mg**

APPENDIX J: PUMP SETTINGS FOR PRACTICE TRIALS

Pump Settings for Practice:

Hydromorphone 0.4 mg/mL

PCA only

0.2 mg dose

8 minutes

12 mg 4 hour limit